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ABSTRACT

This report provides an overview of the research being conducted by the Clinical Studies Group of the Institute for Research on Teaching, whose research is designed to improve the instruction, evaluation, and performance of preservice and inservice reading diagnosticians. The first section of the report describes the use of an inquiry theory of clinical problem solving that analyzes the clinical encounter or the clinical interaction. The second section describes observational studies, including a 1977 study of eight reading specialists using simulated case studies, a reading and learning disabilities study, a classroom teachers study, a diagnostic process and outcomes study, the development and use of a paper problem as an observational instrument, and a study of the relationship between diagnosis and remediation in reading. Other sections describe a study of computer simulation of clinician process and a study of the application of an instructional corollary to teacher training. (MKM)

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CLINICAL PROBLEM SOLVING IN READING: THEORY AND RESEARCH

Doron Gil, Ethelyn Hoffmeyer,
Joel VanRoekel, and Annette Weinshank

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Teachers' thoughts and decisions are the focus of studies currently under way at Michigan State University's Institute for Research on Teaching (IRT). The IRT, founded in April 1976 with a $3.6 million grant from the National Institute of Education, has major projects investigating teacher decision-making, including studies of reading diagnosis and remediation, classroom management strategies, instruction in the areas of language arts, reading, and mathematics, teacher education, teacher planning, effects of external pressures on teachers' decisions, and teachers' perceptions of student affect. Researchers from many different disciplines cooperate in IRT research. In addition, public school teachers work at IRT as half-time collaborators in research, helping to design and plan studies, collect data, and analyze results. The Institute publishes research reports conference proceedings, occasional papers, and a free quarterly newsletter for practitioners. For more information or to be placed on the IRT mailing list please write to: The IRT Editor, 252 Erickson, MSU, East Lansing, Michigan 48824.

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We are all indebted to the research of Professors Arthur Elstein and Lee Shulman, whose Medical Inquiry Study laid the theoretical and methodological foundation for the research program conducted by the Clinical Studies group.

Our special thanks, also, to members of the Clinical Studies (CLIPIR) support staff for all their help in the production of this manuscript.

Clinical Problem Solving in Reading: Theory and Research

Doron Gil, Ethelyn Hoffmeyer,
Joel VanRoekel, and Annette Weinshank[1]

The theoretic structures and resulting studies reported in this paper were designed to investigate the clinical problem-solving skills of experienced reading and learning specialists and classroom teachers as they diagnose, and then propose remediations for, a variety of reading problems. These studies fall under the IRT's Clinical Studies Research Program which seeks to better understand, both theoretically and empirically, the clinical skills involved in diagnosing and remediating reading problems. The program's ultimate goal is to improve the instruction, evaluation, and performance of inservice and preservice practitioners.

Some of the research reported in this paper has been completed; some is ongoing. Individual studies are reported more fully in the papers referenced herein.

Conceptually, the research program is based on the "Inquiry Project" studies in medical problem solving conducted at Michigan State University (Elstein, Shulman, & Sprafka, 1978). The Inquiry Theory which grew out of these medical studies describes the behavioral domain of the clinical encounter as follows: A physician interacts with a case in order to reach diagnostic and treatment decisions about the patient's problems. Specifically, the Inquiry Theory postulates that clinical diagnosis is determined by the

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[1]Doron Gil, Joel VanRoekel, and Annette Weinshank are research interns with IRT's Clinical Studies group. Ethelyn Hoffmeyer is a graduate assistant with that same research program.

interaction of (1) clinical memory (consisting of sets of problems, cues, cue values, diagnoses, treatments, and the relationships among them), (2) clinical strategy (the sequencing of the mental tasks performed by physicians), and (3) the case (Gil, Vinsonhaler, & Wagner, Note 1).

This description of the clinical encounter provides the conceptual framework for our studies in which reading specialists interact with simulated cases of students with reading problems in order to diagnose and propose remediations. The interaction is studied by the use of information-processing methodology as discussed by Elstein, Shulman, and Sprafka (1978).

> The information-processing approach attempts to account for two bodies of fact. First, humans can and do learn to solve a variety of complicated problems. Some of these are so complex that if all potential steps toward a solution were explored, the time needed would be far greater than is ever observed and would in some cases exceed a lifetime. Evidently some planning is required, and labor-saving strategies must be developed. On the other hand, the planning and strategy must be consistent with those characteristics of the human mind that set limits on capability for processing information. As an example of a relevant limit, it appears that human long-term memory is essentially infinite, but that short-term memory has a capacity of only a few symbols . . . . Methodologically, information-processing research generally relies on introspective reports to determine the thought processes, heuristics, symbolic manipulations, or decision rules needed to solve a particular problem. These are formalized by the investigator into a computer program or other model that should perform the task much as the human did, if the detailed specifications are adequate. (pp. 20-21).

Our analyses of the clinical encounter in reading are based on the verbal protocols of participating reading clinicians as they interact with simulated cases of reading difficulty. As Newell and Simon (1972) characterize the process, "It becomes essential to get enough data about each individual subject to identify what information he has and how he is processing it" (p. 12). To know how clinicians ply their trade, we must give them an opportunity to tell us what they are doing while they are doing it.

In summary, the work of the Clinical Studies group is directed toward (1) using the Inquiry Theory of clinical problem solving as a guide in determining the nature of empirical studies in reading and learning disabilities, and (2) using the results of those studies to enlarge and refine the predictive capabilities of the theory.

I. The Inquiry Theory

We and our co-researchers in the Clinical Studies group have been actively involved in the past few years in studying the behavior of clinical problem solvers and in developing a theory to explain such behavior. The resulting formal theoretical structure, which can integrate the numerous concepts and empirical findings on clinical problem solving, has come to be known as the Inquiry Theory of Clinical Problem Solving.

The Inquiry Theory originated in the medical education research "Inquiry Project" at Michigan State University (Elstein, Shulman, & Sprafka, 1978). One major intent of that project was to study problem solving and reasoning in a complex task environment where prior experience was clearly relevant and the data inherently probabilistic.[2] Medical practice seemed to provide the best opportunity for studying problem solving under those conditions. The resulting model of medical reasoning was thus derived mainly from the intensive study of a few medical problems worked up by approximately two dozen physicians.

Not all clinical tasks involve physicians and the medical profession, however. The "clinical model" is also well suited to the study of reading clinicians because it is problem-initiated and problem-directed"

[2]Probabilistic refers to a lack of certainty.

(Elstein, Shulman, & Sprafka, 1978). Thus, the Inquiry Theory of Clinical Problem Solving continues to be developed by the Clinical Studies group (Vinsonhaler, Wagner, & Elstein, Note 2).

The Clinical Encounter

The behavioral domain of the Inquiry Theory is known as the "clinical encounter" and may be defined as the events which occur as a clinician (e.g., a reading clinician, a teacher, or a physician) attempts to solve a problem in a case (student, client, patient, or patient record) by making a diagnosis (What is the problem?) and prescribing a treatment (What can be done to solve the problem?). The clinical encounter, then, is the interaction that occurs when a clinician deals with a case.

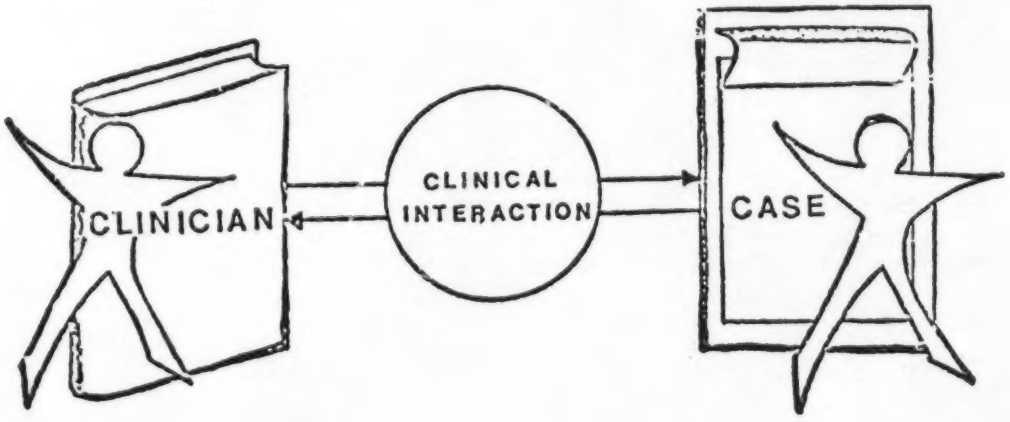

Figure 1: The clinical enounter.

The Clinical Interaction

The Inquiry Theory describes the behavioral domain of the clinical interaction and attempts to predict those characteristics of that interaction which will reoccur (and be observed). The same behaviors may be observed when several clinicians interact with the same case, or when one clinician interacts with several cases. The main elements characterizing the clinical interaction are presented in Figure 2.

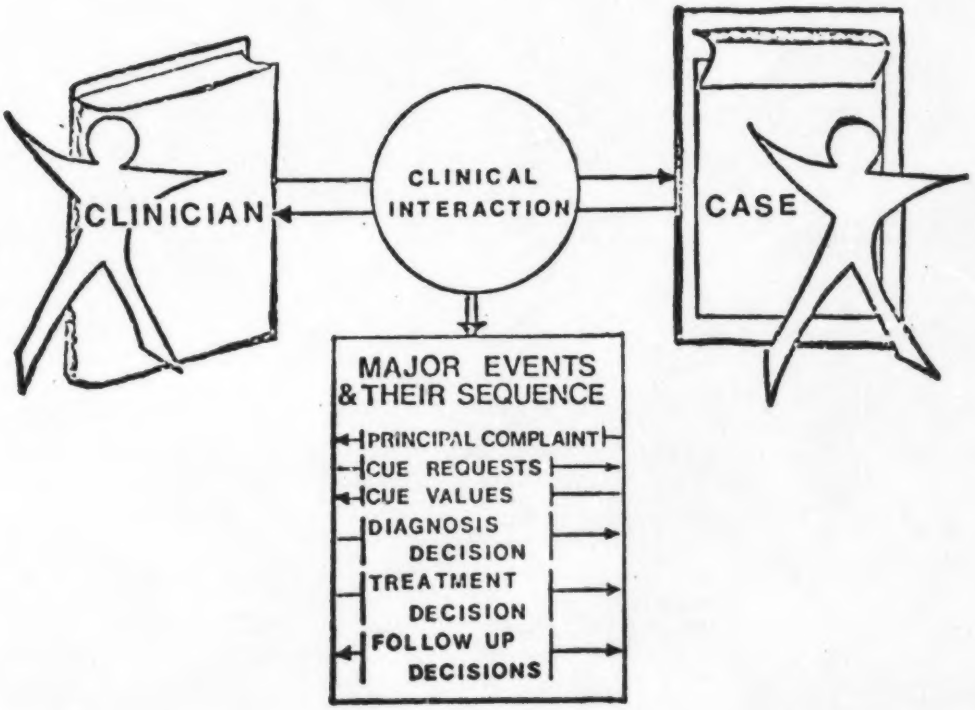

Figure 2: The clinical interaction.

As illustrated in Figure 2, there are six major elements of the clinical interaction: the principal complaint, cue requests, cue values, the diagnosis decision, the treatment decision, and the follow-up decision. The principal complaint is a statement of a symptom initiated by the case. Cue requests are a gathering of case information by the clinician. Cue values are the clinician's association of the significance of the information collected in terms of its relationship to the problem. The diagnosis decision is the determination of the problem by the clinician, while the treatment decision is the selection of treatment seen as being most appropriate. Finally, the follow-up decision is the determination of treatment efficacy.

The Clinical Case

The cognitive elements of a case include:

1. A set of problems (e.g., a Dolch list, indicating inadequate sight word recognition);
2. A set of cue names (items of information, e.g., Dolch Word List, oral reading transcription);
3. A set of cue values which specifies the client's state with respect to the cue (e.g., 70% accuracy on Dolch words, numerous omissions in oral reading); and
4. A set of responses to potential treatments (Figure 3).

Case Simulation

The use of simulated cases is an alternative to presenting clinicians with live clients. A simulated case is designed to elicit many of the same problem-solving behaviors from the clinician as would a live case, but it is much easier to use for research and training purposes. Simulated cases provide for controlled situations, whereas live cases

do not. Relevant informatin (e.g., physical records, background information, test behaviors, etc.) can be collected and stored in a file box (manually-based simulated case), or in a computer file (computer-based

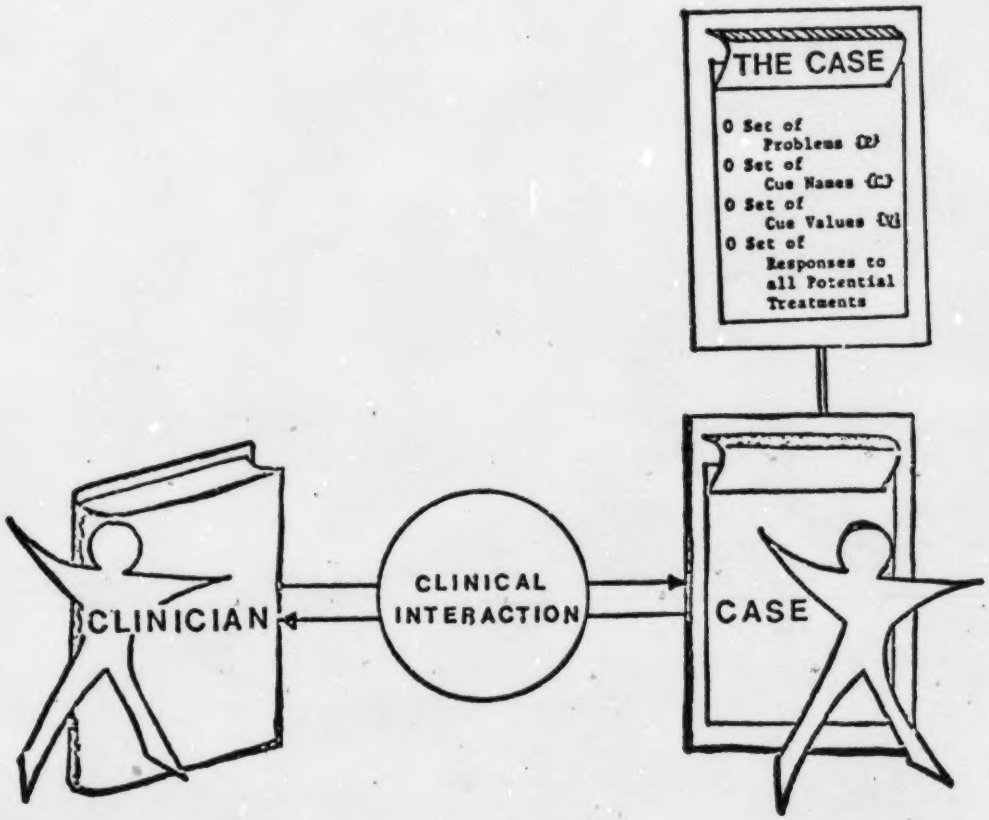

Figure 3: The clinical case.

simulated case) (Lee & Weinshank, Note 3). (See Patriarca, VanRoekel, & Lezotte, Note 4, for a complete discussion and description of simulated cases.)

The Clinician

During a clinical interaction, the behavior of the clinician is

case (Figure 4).

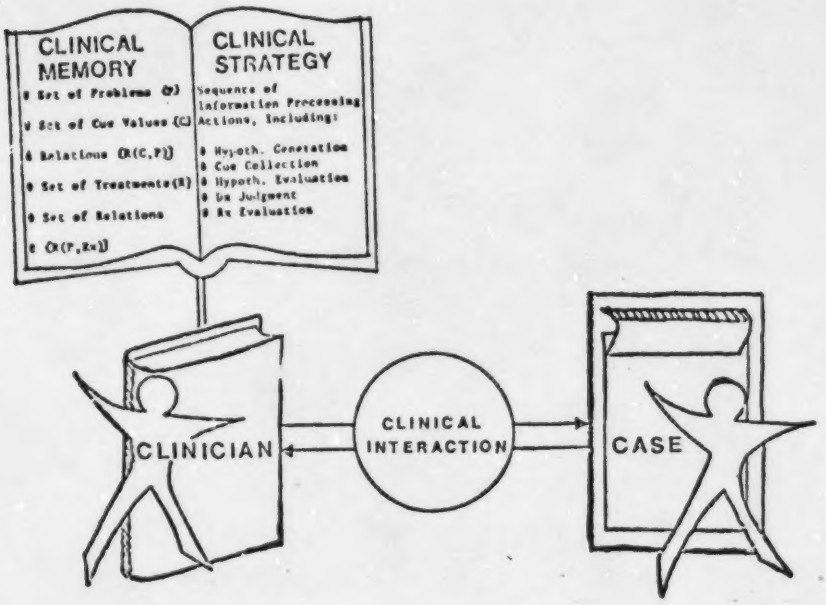

Figure 4: The clinician.

Clinical Memory

Clinical memory may be defined as a set of problems, cues, cue values, diagnoses, treatment descriptions, and the relationships among these.

These relationships are:

1. A set of relations between cues and problems used to infer the presence of problems in a given case based on cues already collected;

2. A set of relations between problems and cues used to determine which cues should be collected next in order to confirm or disconfirm hypotheses currently under consideration;

3. A set of relations between problems and treatments used to evaluate and select treatment plans for diagnosis made for a given case; and

4. A set of relations between treatments and prescriptions used to define the specifics of case management for a treatment plan made for a given case (Vinsonhaler, Wagner, Elstein, & Shulman, Note 5).

Clinical Strategy

The clinician's strategy consists of a sequence of tasks which translate memory into action. These tasks primarily involve information gathering and information processing as the clinician makes decisions about diagnosis and treatment. Those tasks include the following:

Cue acquisition. Cue acquisition is the process by which the clinician decides which information (cues) should be collected and the relative value of those cues selected. Cues amay be chosen on the basis of confirming or disconfirming one or more competing hypotheses concerning the patient's problem, or according to some information-gathering routine.

Hypothesis generation. This is the process of retrieving from memory a number of problem formulations (hypotheses) based on some limited number of cues, and the relations between the cues and problems, which are part of the clinician's memory. Early generation of hypotheses may be used to direct the information-gathering routine.

Cue interpretation. The process by which case information is evaluated in terms of its "fit" with specific hypotheses is known as cue interpretation.

Hypotheses evaluation and diagnosis judgment. This is the process by which the clinician estimates the likelihood of each hypothesis being considered. This is done by eliminating unlikely hypotheses, and by accepting as the diagnosis those hypotheses with a sufficiently high likelihood of being correct.

Treatment evaluation. The process by which the clinician estimates the expected gain for each available treatment for the diagnosed problem is the treatment evaluation. Expected gain is calculated on the basis of the relations between the problem and available treatment plans.

Prescription selection. Here, the relations between treatments and prescriptions are used when the clinician writes out the specifics of the case management.

Corollaries

If the Inquiry Theory is an accurate representation of the events which characterize the clinical encounter (the interaction between case and the clinician's memory and strategy), then certain performance corollaries follow:

1. Agreement Corollary. (A) *Group and Inter-clinician Agreement:* If diagnosis is determined in part by clinical memory and strategy, then similar memories and strategies will result in similar diagnoses across and between clinicians. (B) *Intra-clinician Agreement:* The diagnostic agreement of one individual with himself/herself on the same case over time is at least as great as the diagnostic agreement of that individual with another person on that case, i.e., one person's memory and strategy are more consistent over time than the memories and strategies of two people.

2. Training Corollary. Similarity of diagnoses within a field should be at least as great as similarity of diagnoses across fields, assuming training is different. Different memories and strategies should result in different diagnoses; similar memories and strategies should result in similar diagnoses.

3. Instructional Corollary. Improvement in memory and strategy results in improvement in diagnostic performance.

4. Remedial Corollary. Problems and treatments are associated in memory such that the probability of choosing an effective treatment given a problem that characterizes the case is greater than the probability of choosing a treatment-in-general.

II. Observational Studies

Over the past several years, the Clinical Studies research team has conducted a number of observational studies using simulated cases. These studies were designed to observe the clinical problem-solving behavior of educators with varying degrees of training in reading and educational assessment. They were conducted with three purposes in mind. First, the results of these studies will expand the available body of information concerning clinical problem-solving behavior. Second, the data acquired will assist in the evaluation of the Inquiry Theory as it applies to the diagnosis of reading and learning problems. Third, the data is of potential use to educators attempting to improve educational programs emphasizing diagnosis or diagnostic/prescriptive teaching.

The observational studies research program is divided into six areas of study:

1. The 1977 Observational Study
2. The problem-solving behavior of reading specialists and learning disabilities resource teachers.
3. The clinical problem-solving behavior of classroom teachers as they diagnose a child's reading performance in laboratory and classroom situations.

4. The process and outcomes of diagnostic problem solving among reading clinicians.

5. The construction and use of paper problems to observe the diagnostic problem-solving behavior of reading clinicians.

6. The relationship between diagnosis and remediation in reading.

The 1977 Observational Study

The model for all our studies was the observational study conducted in the spring of 1977 (Weinshank, Note 6). The purpose of this study was to investigate the diagnostic decision-making behavior of a selected group of eight reading specialists. Each subject participated in three observational sessions during which s/he was exposed to simulated cases of reading difficulty. These simulated cases were based on the academic and social behaviors of actual school children, and they represent reading problems that occur regularly in the school setting.

Each observational session involved the interaction of three individuals in two distinct stages.

In stage one (the clinical encounter), the reading specialist (clinical subject) was placed in a small room containing a table, chairs, the materials necessary for interacting with a simulated case, and a one-way vision strip. A second individual, the experimenter, was also present in the room to provide the clinical subject with directions and necessary materials for conducting the observational session. On the opposite side of the vision strip, an experienced reading clinician (the clinical observer) was responsible for recording the interaction between the clinical subject and the simulated case.

In stage two, the "debriefing session," the clinical observer joined the individuals in the room to conduct a step-by-step review of the clinical interaction. During this debriefing session, a series of

questions was posed regarding the clinical subject's behavior while interacting with the simulated case. Each two-stage observational session required approximately four to five hours.

The people involved in a given observational session, as has been previously stated, were the experimenter, a clinical observer, and a clinical subject. The experimenter's task, in general terms, was to oversee the entire observational session. S/he was responsible for providing any necessary directions to the clinical subject, presenting all simulated case materials requested by the clinical subject, recording all information requested during the clinical encounter, and reorganizing all materials necessary to conduct the debriefing session. The clinical observer's responsibilities included monitoring an audio tape recording of the observational session, generating a verbatim transcript of the observational session, recording the time spent on various cues requested during the clinical encounter, and providing any additional assistance necessary during the observational session. The clinical subject's task was to collect information concerning the case as s/he normally would and attempt to verbalize this process throughout the clinical encounter. Following data collection, the clinical subject prepared a written summary of the diagnosis and generated a treatment program for the particular case.

Procedures for the debriefing session were altered somewhat from those of the clinical encounter. The debriefing session was an attempt to reconstruct the clinical encounter to determine why particular cues were requested, how specific cues were interpreted, which hypotheses were formulated by the introduction of specific cues, and which cues confirmed or disconfirmed existing hypotheses. It was the clinical observer's

task to question the clinical subject on these matters. The experimenter's task was to write a verbatim transcript of the session and to record the session on tape.

Following the debriefing session, the clinical subject was given the opportunity to revise the written diagnosis in case the debriefing session had altered his/her thinking about the case.

The final product of the observational session was a protocol of the cues collected, times of cue requests, clinician's comments, and a written diagnosis and remediation plan.

The body of data generated by the 1977 study was analyzed in terms of the Agreement Corollary previously discussed. Hypothesis A predicted that clinical subjects employing common memories and common strategies would produce similar diagnoses. The mean commonality score (a measure of the degree of agreement of a given reading clinician with the total group of reading clinicians) was .55. However, the average individual diagnostic correlation between any two clinicians, or inter-clinician agreement (a measure of how closely each individual correlates with every other individual) was -.07.

Hypothesis B of the Agreement Corollary predicted that for a given case, one clinician interacting with equivalent forms of that case will produce diagnoses exhibiting equal or greater agreement than the diagnoses of different clinicians on the same case. In support of that hypothesis, we found that the intra-clinician (a clinician's diagnosis on a case compared to his/her diagnoses on equivalent forms of the case) correlation coefficient was .17.

The hypothesis that similar memories and strategies result in similar diagnoses was thus partially confirmed. Similar memories and strategies lead to similar group diagnoses (mean agreement = .55). Mean intra-

clinician agreement (.17) is, as predicted, higher than mean inter-clinician agreement (-.07) but both are inadequate.

Finally, a prediction was made that clinicians using common memories and strategies would select cues (case information) in a similar manner. The mean correlation between cue selection of different clinicians for the same case was .18. Thus, there is a modest relationship between common memory and strategy and common cue selection.

Several conclusions can be drawn from the above data. It appears that as a group, the reading clinicians in this study agreed to a reasonable degree among themselves. The individual diagnostic agreement, however, is not adequate, and the diagnostic agreement between any two clinicians is near zero. Hopefully, both these levels of agreement can be improved, either through training or decision aids to standardize the vocabulary used.[3] Additionally, from the range of behaviors exhibited by clinicians in this study, clinical memories and strategies appear to be deduced from a model of reading and learning adopted by the clinician. The explicitness of this model seems to determine the diagnostic consistency of the clinician. (For more detailed information, see Vinsonhaler, Note 7.)

Reading and Learning Disabilities Study

This study, a test of the Training Corollary, focused on the problem-solving behavior of reading specialists and learning disabilities resource teachers. Many children are involved in more than one special

[3]The diagnostic writeups from the study revealed the absence of a standard diagnostic vocabulary. This undoubtedly was responsible for some of the disagreement across clinicians.

instructional program outside the regular classroom. The purpose of this study is to determine if children's behaviors are conceptualized, diagnosed, and treated in different manners depending on the type of specialist with which they interact (VanRoekel, Note 8).

The study was proposed with the following objectives in mind:

1. To identify the types of measures typically used by clinicians representing the fields of reading and learning disabilities when they interact with identical cases of educational difficulty.

2. To determine if there are systematic differences between these two groups of clinicians with regard to the type of data collected, the amount of data collected, the degree to which that information is used in a diagnostic summary, and the diagnostic conclusions drawn.

3. To compare problem-solving processes and diagnostic products of reading clinicians and learning disabilities resource teachers employed in public schools with a group of senior clinicians.

4. To explore the application of the Inquiry Theory to the diagnosis of reading and learning problems.

Two groups of 10 clinicians representing the fields of reading and learning disabilities were exposed to simulated cases of reading and learning disability. Clinicians were allowed 60 minutes to interact with the case and then instructed to generate a diagnostic summary. Preliminary analysis of the data indicates tremendous within- and between-group variation with respect to the number of cues collected on a given case, the types of cue collected on a given case, the interpretation given to various cues collected during diagnosis, the length and specificity of a written diagnostic workup, and the amount of agreement between these clinicians and a small group of expert clinicians.

Classroom Teachers Study

This study investigated the clinical problem-solving behavior of classroom teachers as they diagnosed a child's reading performance in

laboratory and classroom situations (Gil, Note 9). As such it deviated from previous observational studies, which focused on the problem-solving behavior of reading specialists and learning disabilities personnel.

The rationale for the study was as follows: There are too many children in today's schools who experience reading difficulties which, in turn, lead to learning and emotional problems. Early identification of these problems is essential for remediation and to prevent such problems from becoming more severe reading cases (Gil, Vinsonhaler, & Sherman, Note 10). Since reading specialists usually treat only the most severe cases of reading difficulty, early identification should be made by classroom teachers who interact with and observe children's reading behavior on a continuous basis.

The study's objectives were to investigate the clinical problem-solving behavior of classroom teachers as they diagnosed a child's reading problems, and to explore the similarities and differences between teachers' diagnostic practices in experimental and classroom situations.

Ten teachers participated in the study. They all went through two procedures: (1) interacting with a simulated case of reading difficulty in a laboratory situation, and (2) being observed and interviewed in their own classrooms.

Interaction with simulated cases of reading difficulties in a laboratory situation. Each one of the 10 participating teachers interacted with one simulated case at two different times. The interactions followed procedures similar to those in the 1977 Observation Study described earlier. The simulated cases, developed by Dr. Rebecca Barr, University of Chicago, were built around materials available to the teacher in a regular classroom setting; they made use of children's natural language patterns.

Classroom observations and interviews. After a period of a few weeks following the laboratory experiment, each teacher was observed in her classroom for one reading session and was then interviewed about her reading instruction and diagnosis practices.

Results are not yet available.

Diagnostic Process and Outcomes Study

A major objective of the IRT Clinical Studies Research Program is to develop and empirically test clinical problem-solving theory and its application in the field of reading. This, in part, involves the explication of the clinical problem-solving behavior of reading clinicians. The Diagnostic Process and Outcomes Study worked toward this objective by conceptually replicating[4] the 1977 Observational Study to verify the results of that study and improve and build upon it (Hoffmeyer, Note 10).

Improvements were directed to four general areas: (1) improving the objectivity of the diagnostic procedures, (2) improving cost/efficiency, (3) broadening the range of individual variables, and (4) eliminating a cue list (a list of materials contained in a case, such as background information, specific test data, etc. which might be helpful in diagnosing a reading problem).

Three basic components of the Inquiry Theory were tested in this study, namely the impact of clinical memory and strategy on: (1) the diagnostic agreement of clinicians, (2) cue collection, and (3) hypothesis generation.

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[4]Conceptual replication study may be defined as a copy of the basic concepts of design or intent, not the particular conditions (i.e., a sister study).

The subjects for this study were chosen from a list of reading clinicians who had taught the summer institute courses in reading diagnosis and remediation offered by Michigan State University. All subjects were randomly assigned to the eight cases used in the study. Each subject was asked to diagnose three cases, one case per session.

The subjects, one at a time, were asked to interact with materials in a simulated case. Case materials were contained in a file box, and the examiner provided the information by handing materials to the subject at the subject's request. The subject was given 45 minutes to interact with the case materials and was allowed to take notes and retain all items of information requested throughout the session.

Following the case interaction, the clinician was asked to write a diagnosis and a remediation, transfer his/her written diagnosis to a diagnostic check list, and then indicate for each of the reading factor statements whether it was a strength, a weakness, or an observation.

Next, the subject was asked to complete a hypothesis/observation check list, responding to the questions of why s/he asked for each piece of information (cue) and what the information told him/her (hypotheses, observations, or hunches). Subjects were asked to explain each of their responses.

The above procedures were followed for each of the three clinical sessions. Additional procedures for the third session included questions regarding the final case and the clinician's opinion as to how the student might be evaluated on four areas of reading: instant word recognition, word analysis, reading fluency, and reading comprehension.

Again, the results are not yet available.

The Development and Use of the Paper Problem as an Observational Instrument

This study proposes to develop and test an alternate form of the simulated case -- a paper problem[5] (Stratoudakis, Note 12). The study investigates whether or not the paper problem can be substituted for the less efficient simulated case as an instrument in collecting data on diagnostic problem solving.

If the data derived from the paper problem instrumentation is at least as representative of diagnostic decision making as that derived from the simulated case form appears to be, then the paper problem would hold distinct advantages over the simulated case as a data collection instrument. First, the paper problem can be administered to groups, while the simulated case requires individual administration. Also, the paper problem is planned to require not more than one and a half hours to administer, while the simulated case requires approximately three hours. At any hourly rate, then, it is twice as expensive to pay subjects to interact with a simulated case than to pay them to interact with a paper problem.

The subjects of this study will be 20 graduate students who have taken Education 830E, Diagnosis of Reading Difficulty, at Michigan State University under Dr. George Sherman. Ten subjects will be assigned randomly to the simulated case condition and 10 to the paper problem condition. The two data collection instruments are alike in that they represent the same child with a typical reading problem. They are different in format and size. The simulated case is presented in a metal file box, while the paper problem is presented in a booklet.

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[5]The information stored in a file box as a simulated case is reformatted so that it can be contained in a standard three-ring notebook. The paper case (problem) requires no experimenter to provide information because the subject paces himself/herself through the material.

Data will be collected from each subject on two separate cases during two separate sessions. The procedures followed within each session are basically the same as the procedures followed in previous observational studies.

Results are not yet available.

The Relationship Between Diagnosis and Remediation in Reading

The Remedial Corollary to the Inquiry Theory proposes that problems and treatments are associated in probabilistic fashion such that for any given problem, some treatments would be more likely to be selected than others. This corollary was tested in a pilot study (Weinshank, Note 13) investigating the relationship between diagnosis and remediation in reading. For this pilot, the remediation plans proposed by the clinicians who participated in the 1977 Observational Study were used. The major finding was that the relationship between problems stated in the diagnosis and treatments proposed in the remediation was only moderate, with a correlation of .40.

Examination of the written diagnoses and remediations revealed that there was no one-to-one correspondence between problems and treatments. There were categories of statements other than problems and treatments in both the diagnoses and the remediations whose function was not accounted for by the Problem-Treatment Corollary.

To investigate more systematically the relationship between diagnosis and remediation, a full-scale observational study focused on remediation took place during the summer of 1979. (Weinshank, Note 14). The study, which involves simulated cases, is directed toward two goals: (1) extending the methodology of clinical problem solving research from the area of diagnosis to that of remediation, and (2) objectively measuring the specific nature of the relationship between diagnosis and remediation.

The study has four major objectives:

1. To categorize and standardize diagnostic statements by having the clinicians transfer their written diagnoses to a standardized diagnosis check-list.

2. To categorize and standardize treatment statements by having the clinicians transfer their written remediations to a standardized remedial check-list.

3. To obtain a list of matches between diagnostic statements and remedial statements by having the clinicians match statements from the standardized diagnostic and remedial check-lists.

4. To find out, through debriefing sessions with clinicians, why each diagnostic statement was or was not remediated, and if remediated, why one treatment was chosen over another.

III. Computer Simulation Studies

Another approach through which knowledge of effective clinical problem solving can be gained involves computer simulation studies of the clinical problem-solving behavior of reading specialists. This form of research uses the computer to simulate a clinician as s/he interacts with simulated cases of reading difficulties (Vinsonhaler, Wagner, & Gil, Note 15).

According to the Inquiry Theory, the behavior of a clinician is a function of his memory and strategy (Vinsonhaler, Wagner, & Elstein, Note 2). Therefore, a simulated clinician can be built by simulating a memory, a strategy, and the interaction between them. Changes in memory, strategy, or both will be reflected in changes in the simulated clinician's performance. Computer simulation studies can then simulate a clinician as s/he interacts with a simulated case of a child having reading difficulties. Throughout this simulated interaction, the computer uses its memory and strategy to arrive at a diagnosis for a child. In so doing, it uses a process of diagnosis similar to the one applied by human clinicians. The interaction between the computer clinician and a case starts when the

computer receives the initial contact about the case: some basic information regarding the child's status in reading. With this information the computer proceeds to collect more information, on the basis of which it generates some hypotheses about the child's reading problems. Then the simulated clinician confirms or disconfirms these hypotheses by collecting information. (This is called hypothesis-directed inquiry.) After collecting a certain amount of information about the case, the simulated clinician begins its final diagnosis.

In creating different simulated clinicians, different memories and strategies can be used. These different clinicians may then interact with various cases to reach diagnostic decisions. The effects of these diagnostic outcomes are analyzed, and an increased understanding of the clinical diagnostic process gained.

In what follows, we will describe two simulation studies, one a routine cue collection study, and the other an early hypothesis generation study.

Routine Cue Collection Study

This study focused on the impact of routine cue collection (the collection of some basic information about a case prior to the beginning of hypotheis generation) on the clinician's performance. Observational studies with human clinicians have indicated that some clinicians use a routine cue collection procedure at the beginning of every interaction with a new case, while other clinicians do not use such a routine.

How significant is this routine cue collection to the diagnostic process? To answer this question, several simulated clinicians were instructed to diagnose cases of reading disability. The clinicians were further programmed to either use or not use routine cue collection.

A simulated clinician using routine cue collection proceeded through

the following steps: First, the initial contact information was collected. Second, routine cues were collected, i.e., a set of cues that seemed relevant to the information already collected. Third, hypotheses were generated. Fourth, a diagnosis judgment was made. Finally, a diagnosis termination judgment was made, i.e., whether diagnosis should be continued.

A simulated clinician not using routine cue collection proceeded through all the steps mentioned above except Step 2, the collection of routine cues.

Researchers analyzed the performance of these two kinds of simulated clinicians as well as the performance of human clinicians who diagnosed the same cases in one of the observational studies. They found that the simulated clinicians using routine cue collection significantly outscored those without such a routine, but they still fell short of human performances (Gil, Wagner, & Vinsonhaler, Note 16).

Early Hypothesis Generation Study

This study, also using the simulated clinicians, investigated the processes of hypothesis generation as they are affected by different certainty thresholds for considering a hypothesis. Hypothesis generation is the process of selecting which hypotheses to consider in the diagnostic workup. The certainty threshold is a measure of how likely a hypothesis must be initially to be seriously considered as a possible diagnosis. The higher the threshold, the fewer the number of hypotheses which will be considered because few hypotheses will have sufficiently high likelihoods. The lower the threshold, the greater the number of hypotheses that will be considered, because more hypotheses will have likelihoods greater than the threshold. This differentiation between high and low thresholds can be seen in medicine, where students are trained to accept many hypotheses

at the beginning of their encounter with a patient, narrow these hypotheses down to the most probable ones, and study these very carefully. This means that these students will be more receptive to new hypotheses early in the session and less receptive as the session proceeds.

To study this phenomemon, several simulated clinicians were created. Some of them, after receiving the initial contact and collecting the routine cues, were programmed so that their threshold of hypothesis acceptance rose during the diagnostic session. In the beginning, the threshold was very low and many new hypotheses could be generated; at the end, this threshold was very high, so few new hypotheses could be generated.

By contrast, some simulated clinicians were created to be equally receptive to new hypotheses throughout the entire interaction. Like the other clinicians, they started the interaction by receiving the initial contact and collecting routine cues. However, when they generated hypotheses, the threshold of acceptance was low throughout the entire session.

The results indicate that both kinds of simulated clinicians -- those with varying thresholds throughout the session and those with fixed, low thresholds throughout the entire session -- did, in fact, generate most of their hypotheses at the beginning of the interaction. This indicates that early hypothesis generation may be a necessary result of hypothesis-directed inquiry (Gil, Wagner, & Vinsonhaler, Note 16).

IV. Application Study

The Instructional Corollary, which derives from the Inquiry Theory, states that if, in fact, clinical interaction is determined by the

clinician's memory and strategy, then clinician performance during the interaction may be improved by alterations in clinical memory and strategy.

During the summer of 1977, a study was conducted to apply the Instructional Corollary of the Clinical Problem-Solving Theory (Sherman, Note 18). The 36 subjects were reading specialists and classroom teachers enrolled in a graduate reading diagnosis course. The objectives of this exploratory study were to examine the following questions:

1. Do clinical memory and strategy relate to performance in diagnosis?
2. Can clinical memory and strategy be manipulated by independent variables (such as decision and learning aids, and practice with feedback) so that teachers and specialists can be trained to diagnose reading difficulties in a manner similar to effective senior reading clinicians?

To address these questions, the instruction in the graduate reading diagnosis course was explicitly studied by this principle of the Inquiry Theory: Improvement in memory and strategy result in improvement in diagnostic performance.

Procedures in this study included pretests, clinical training in diagnosis, and posttests. Both pre- and posttests included a Memory Battery Association Test and a Diagnostic Performance Test using simulated cases of reading difficulty. The Memory Battery Association Test included three tests: (1) Factor to Cue Association Test (given a hypothesized factor, e.g., inadequate basic sight word vocabulary, the student was asked to list no more than five findings which would confirm or disconfirm the given hypothesis), (2) Cue to Factor Association Test (given a list of findings, e.g., trouble with little words, 60% correct on Dolch first-grade list, the student was asked to generate no more than five problems and/or strengths suggested by the findings given), and (3) Information to Cue Association Test (given a piece of information,

e.g., an annotated oral reading paragraph, the student was asked to identify "important findings" or diagnostic cues, that is, something observed which may be important in diagnosing a case).

The Diagnostic Performance Test examined each student's ability to diagnose a simulated case of reading difficulty. Both tests were timed, and the identical materials were used as both pre- and posttest measures.

Clinical training consisted of 30 hours of instruction in a five-week course. Four different instructional groups were trained. These groups were established not as comparisons of each other, but rather to insure that the best possible training conditions were met.

Group one represented a traditional approach in that each student identified two children with suspected reading problems. The task for each student was to administer, score, interpret, and write up a formal diagnosis for both of these children. Instruction in this group involved explanation of the uses of various tests and discussion of the diagnostic problems generated by the children being examined.

Group two used simulated cases instead of live cases for its diagnostic encounters. These, too, were reviewed and analyzed in daily sessions with the instructor.

Group three also used simulated cases but was additionally provided with decision aids in the form of decision flow charts and a standardized diagnostic categorization to be used in writing up the diagnosis.

Group four was originally scheduled to use computer-based simulations combined with an automated preceptor to provide feedback on appropriateness of information requested and diagnostic strategy. Unfortunately, computer response time declined drastically over the course of the study and necessitated the use of group three procedures with this group.

Despite certain experimental limitations, the results of this application study suggest that clinical memory and diagnostic performance are related, and that training can improve both. There was a dramatic change in performance on both the Memory Battery Association Test and the Diagnostic Performance Test at the end of the instructional period (the mean pretest score was .16, while the mean posttest score was .47). As predicted by the Instructional Corollary, changes in diagnostic performance were strongly related to changes in clinical memory and strategy. (See Sherman, Note 18 for a detailed discussion of this study.)

VI. Some Final Words

The research program described in this paper, while conducted by individual researchers, was linked together over time by a common theoretical base and methodology. The benefits resulting from conducting research in this fashion are numerous, including: (1) improvement of materials, (2) refinement of measurement techniques, (3) clarification of methods, (4) opportunity to replicate results, (5) development of a more accurate representations of the state of nature under discussion, and (6) formulation of a more accurate sense of how to alter that state of nature if alteration is considered necessary.

Empirical verification of a theory is a long iterative process requiring cooperative effort. The work reported here represents such an effort. The Inquiry Theory has served to direct the empirical research, the results of which have been used both to refine the theory and to increase its predictive powers.

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